# SPECIFICATION

# CABLE ASSEMBLY WITH INTERNAL CIRCUIT MODULES

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** Subject matter of this patent application is related to pending U.S. Patent Application Serial Nos. 10/316,547, filed on December 10, 2002 and entitled "CABLE ASSEMBLY"; 10/278,520, filed on October 22, 2002 and entitled "ELECTRICAL CABLE CONNECTOR"; about to be filed and entitled "CABLE ASSEMBLY WITH IMPROVED GROUNDING MEANS"; and an unknown serial number filed on June 25, 2003 and entitled "CABLE ASSEMBLY WITH INTERNAL CIRCUIT MODULES", all of which are invented by Jerry Wu and assigned to the same assignee as this application.

## BACKGROUND OF THE INVENTION

### 1. FIELD OF THE INVENTION

**[0002]** The present invention generally relates to a cable assembly, and particularly to a cable assembly having a plurality of circuit boards for high speed signal transmission.

### 2. DESCRIPTION OF RELATED ART

**[0003]** With the development of communication and computer technology, high density electrical connectors are desired to construct a plurality of signal transmitting paths between two electronic devices. Each of these electrical connectors provides a plurality of circuit boards to thereby achieve improved signal transmission of different electrical characteristics through the connector. Such high density electrical connectors, such as cable assemblies, are widely used

in internal connecting systems of severs, routers and the like requiring high speed data processing and communication.

**[0004]** U.S. Pat. No. 6,217,364, issued to Miskin et al., discloses a cable assembly including an insulating housing formed by a pair of substantially identical housing halves and an electrical cable with a plurality of wires terminated to conductive terminals overmolded in a plurality of thin flat wafers. The housing halves combine to define an interior cavity having a front opening and a rear opening. The wafers are closely juxtaposed in a parallel array and are positioned within the interior cavity of one of the housing halves such that the cable projects out of the rear opening of the cavity. The other housing half is then to completely enclose the cable and wafer subassembly. However, the cable and wafer subassembly are retained in the housing by securing the housing halves together through bolts and nuts, thereby complicating the assemblage of the cable assembly. Furthermore, an engagement of the housing halves is easy to become loose due to vibration during the transportation and other matters, whereby the cable and the wafer subassembly cannot be stably retained in the housing. Thus, an electrical connection is adversely affected between the cable assembly and a complementary connector.

**[0005]** U.S. Patent Nos. 5,924,899 (the '899 patent) and 6,102,747 (the '747 patent), both issued to Paagman, each disclose a cable assembly. Referring to FIGS. 4a-4c and 5a-5c of the '899/'747 patent, the cable assembly includes an insulating housing with a plurality of parallel slots defined therein and a plurality of modules received in the slots of the housing. Each module includes a circuit substrate, a receptacle carrier having a plurality of fork contacts at one end of the substrate and an insulation displacement contact (IDC) carrier at the other end of the substrate opposite the terminal carrier. The insulation displacement carrier has insulation displacement contacts connecting with conductors of corresponding cables. The

modules each are retained in the housing through an interference fit with the housing. When the cable assembly is required to disengage from a complementary connector, a pulling force is exerted on an exposed end of the cable for releasing the engagement between the cable assembly and the complementary connector. However, the modules may be pulled back with regard to the housing, thereby adversely affecting an electrical engagement when the cable assembly mates with the complementary connector again. Furthermore, an additional device is employed to bond the cables together, thereby increasing the cost of the production.

**[0006]** Hence, an improved cable assembly is highly desired to overcome the disadvantages of the related art.

## BRIEF SUMMARY OF THE INVENTION

**[0007]** Accordingly, it is an object of the present invention to provide a cable assembly having strain relief means for substantially resisting a pulling force exerted on a cable thereof.

**[0008]** It is another object of the present invention to provide a cable assembly having both single-ended signal modules and differential signal modules.

**[0009]** In order to achieve the above-mentioned objects, a cable assembly in accordance with the present invention for engaging a complementary connector comprises an insulating housing, a plurality of first and second circuit modules received in the housing, and a two-piece cover cooperating with the housing for retaining the circuit modules. Each circuit module includes a circuit board accommodated in the housing. Each first circuit module includes a plurality of first coaxial cables for transmitting single-ended signals and each second circuit module includes a plurality of second cables for transmitting differential pairs of signals.

The first and the second circuit modules are staggeredly arranged with each other.

**[0010]** Other objects, advantages and novel features of the invention will become more apparent from the following detailed description of the present embodiment when taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0011]** FIG. 1 is a perspective view of a cable assembly in accordance with the present invention;

**[0012]** FIG. 2 is another perspective view of the cable assembly;

**[0013]** FIG. 3 is an exploded, perspective view of the cable assembly shown in FIG. 1;

**[0014]** FIG. 4 is an exploded, perspective view of the cable assembly shown in FIG. 2;

**[0015]** FIG. 5 is a perspective view of a first circuit module;

**[0016]** FIG. 6 is an exploded, perspective view of the first circuit module shown in FIG. 5;

**[0017]** FIG. 7 is another perspective view of the first circuit module;

**[0018]** FIG. 8 is an exploded, perspective view of the first circuit module shown in FIG. 7;

**[0019]** FIG. 9 is a perspective view of a second circuit module;

**[0020]** FIG. 10 is an exploded, perspective view of the second circuit module

shown in FIG. 9;

**[0021]** FIG. 11 is another perspective view of the second circuit module;

**[0022]** FIG. 12 is an exploded, perspective view of the second circuit module shown in FIG. 11; and

**[0023]** FIG. 13 is a rear plan view of the cable assembly.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0024]** Reference will now be made to the drawing figures to describe the present invention in detail.

**[0025]** With reference to FIGS. 1 and 2, a cable assembly 1 in accordance with the present invention comprises a front insulating housing 10, a plurality of circuit modules 20 received in the front insulating housing 10, and a two-piece rear cover 30 together with the front insulating housing 10 for retaining the circuit modules 20.

**[0026]** Referring to FIGS. 3 and 4, the front housing 10 is generally in a rectangular shape. The housing 10 has a front mating port 11 in a front mating face 100 which faces a complementary connector (not shown) and a rear chamber 12 in a rear face 102. The housing 10 defines a plurality of parallel channels 14 extending in a front-to-back direction communicating with the front mating port 11 and the rear chamber 12 and a plurality of grooves 16 which are aligned with the channels 14. The housing 10 further defines a plurality of recesses 17 respectively in a top face 104 and a bottom face (not labeled) and a plurality of depressions 170 recessed downwardly from the corresponding recesses 17. An aperture 18 is defined through opposite side faces 106 of the housing 10 in a direction substantially perpendicular to the extending direction of the channels 14.

**[0027]** Continuing to FIGS. 3 and 4, the rear cover 30 comprises a split body having a first half 31 and a second half 32. Each half 31, 32 has a top panel 330, a bottom panel 332 and a side panel 334 formed between the top panel 330 and the bottom panel 332. Each half 31, 32 forms a pair of latches 336 extending forwardly from front edges of the top and bottom panels 330, 332, a plurality of dowel pins 337 and corresponding holes 338 for joining the first half 31 and the second half 32 together. Each latch 336 has a projection 3360 formed at a free end thereof. The rear cover 30 defines a bore 300 extending through the side panels 334 thereof. It should be noted that any other suitable connecting means may be employed to connect the first and second halves 31, 32. This split design helps to facilitate the assembly and installation of the cover 30 onto the housing 10 over the circuit modules 20. Understandably, the first and the second halves 31, 32 can be integrally formed with each other before assembling to the housing 10, if desired.

**[0028]** The circuit modules 20 comprise a plurality of first circuit modules 20a and a plurality of second circuit modules 20b, which are identical with each other in structure thereof, respectively. An exemplary one of the first circuit modules 20a is shown in FIGS. 5-8. Each first circuit module 20a comprises a circuit board 22a and a plurality of single-ended coaxial cables 23a electrically and mechanically connecting with the circuit board 22a. The circuit board 22a includes a dielectric substrate made of conventional circuit board substrate material, a plurality of conductive signal traces (not labeled) on one side of the substrate for providing electrical paths through the cable assembly 1 and a plurality of grounding traces (not labeled) on both sides of the substrate for grounding purpose. Each circuit board 22a comprises a front edge portion 220a provided for engaging with the complementary mating connector and a rear edge portion 224a to which the cables 23a are mechanically connected. A through hole 222a is provided on the circuit board 22a which aligns with the aperture 18 of the housing 10 and a plurality of cavities 226a are defined adjacent to the rear edge portion 224a.

**[0029]** The single-ended coaxial cables 23a of each first circuit module 20a are arranged in a common plane. As well known, each single-ended coaxial cable 23a comprises a conductive core 231a surrounded by a dielectric shield (not labeled), a metal braid 232a outside the dielectric shield, and a jacket 233a at the outmost side of the cable 23a. At a distal end of each coaxial cable 23a, a length of dielectric shield is stripped to expose a corresponding length of conductive core 231a. The bare conductive core 231a is soldered to the signal trace on the circuit board 22a from one side thereof. As can be best seen in FIGS. 6 and 8, in the preferred embodiment, the cables 23a of each first circuit module 20a are separated into two groups, each group comprising two pairs of coaxial cables 23a with a gap 27 being defined therebetween.

**[0030]** The first circuit module 20a also comprises a first grounding plate 24a and a cable clamp 25 adapted for being applied to the cables 23a. The first grounding plate 24a is preferably a copper tape and is formed with a plurality of tabs 242a positioned at a periphery thereof. The first grounding plate 24a is attached to the circuit board 22a from a side opposite to the conductive cores 231a of the cables 23a with the tabs 242a being retained in the cavities 226a of the circuit board 22a to thereby secure the first grounding plate 24a thereon. The end of each coaxial cable 23a is stripped to further expose a length of braid 232a, the exposed braid 232a being soldered to the first grounding plate 24a for grounding purpose.

**[0031]** The cable clamp 25 includes a first section 251 and a second section 252 both are stamped and formed from metal tapes. The first section 251 defines a plurality of rooms 253 and forms a plurality of bridges 254 between adjacent rooms 253. Each bridge 254 defines a pair of openings 255 at opposite ends thereof. The second section 252 includes a body portion 256 and two rows of tails 257 upwardly extending from two opposite sides of the body portion 256. The first and

second sections 251, 252 clamp ends of the cables 23a from opposite sides with the tails 257 of the second section 252 being locked in corresponding openings 255 of the first section 251. The ends of the cables 23a are depressed by the body portion 256 of the second section 252 such that they are partially pressed into corresponding rooms 253 of the first section 251. The first and second sections 251, 252 further define a plurality of through holes 266 which are aligned with corresponding gaps 27 between adjacent pairs of cables 23a of a same group.

**[0032]** It should be noted here that an end of each coaxial cable 23a is stripped to further expose a length of braid 232a, the exposed braid 232a being soldered to the first grounding plate 24a attached on an opposite side of the circuit board 22a to provide not only a grounding function but a strain relief function for the cable 23a.

**[0033]** Similarly, an exemplary one of the second circuit modules 20b is shown in FIGS. 9-12. Each second circuit module 20b comprises a circuit board 22b and a plurality of cables 23b electrically and mechanically connecting with the circuit board 22b. The circuit board 22b includes a dielectric substrate, a plurality of conductive signal traces (not labeled) on one side of the substrate for providing electrical paths through the cable assembly 1 and a plurality of grounding traces (not labeled) on both sides of the substrate for grounding purpose. The arrangement of the traces printed on the circuit board 22b of the second circuit module 20b is different from that of the first circuit module 20a because the first circuit module 20a is structured for transmitting single-ended signals while the second circuit module 20b is structured for transmitting differential pairs of signals. Each circuit board 22b comprises a front edge portion 220b provided for engaging with the complementary mating connector and a rear edge portion 224b to which the cables 23b are mechanically connected. A through whole 222b is provided on the circuit board 22b which aligns with the aperture 18 of the housing 10 and the

through hole 222a of the first circuit module 20a.

**[0034]** Each cable 23b of the second circuit module 20b comprises a pair of differential wires 231b soldered to the signal traces on the circuit board 22b and a grounding wire 232b soldered to the ground traces. The second circuit module 20b also comprises a second, planar grounding plate 24b attached to a side of the circuit board 22b opposite to the cables 23b soldered on the other side. The second circuit module 20b further includes a cable clamp 25. The cable clamp 25 of the second circuit module 20b is substantially same to that of the first circuit module 20a and will not be described here again.

**[0035]** In assembly, the circuit modules 20 are inserted into the channels 14 of the housing 10 from the rear face 102 with the circuit boards 22a, 22b being substantially retained in the grooves 16. First fastening elements 40 are inserted into the through-holes 266 of the cable clamps 25 for locking the circuit modules 20 together for strain relief purpose. A second fastening element 50 is inserted into holes 222a, 222b defined in the circuit boards 22a, 22b through the aperture 18 of the housing 10. The second fastening element 50 is further fastened to the housing 10 for keeping the circuit modules 20 in their original positions rather than be pushed back when the cable assembly 1 mates with the complementary connector, thereby stably retaining the circuit modules 20 in the housing 10.

**[0036]** The first and second halves 31, 32 of the cover 30 are assembled to the housing 10 with the projections 3360 of the latches 336 mechanically engage the depressions 170 of the recesses 17. At the same time, the first and second halves 31, 32 are connected by an interference engagement between the dowel pins 337 and the corresponding recesses 338. A third fastening element 60 is inserted into the bore 300 of the cover 30 for retaining the circuit modules 20 in the cover 30.

**[0037]** It is noted that since the circuit modules 20 are stably retained by the front housing 10 and the rear cover 30 via the second and third fastening elements 50, 60, a reliable electrical engagement is ensured between the cable assembly 1 and the complementary connector. It is also noted that the cables 23 are clamped by the cable clamps 25, more importantly, the cable clamps 25 are locked together via the first fastening element 40, whereby a pulling force exerted on the cables 23 can be substantially released.

**[0038]** Particularly referring to FIG. 13, a rear plan view of the cable assembly is shown. The first circuit modules 20a and the second circuit modules 20b are staggeredly arranged. In the preferred embodiment, each pair of second circuit modules 20b are sandwiched between two first circuit modules 20a, and one second circuit module 20b is positioned at the rightmost side of the cable assembly 1. Obviously, the arrangement of the first and second circuit modules 20a, 20b is changeable in order to meet different requirements conducted by different users.

**[0039]** It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.